Executive Summary

Understanding vehicle activity patterns both spatially and temporally is critical for building accurate mobile source emissions inventories. Vehicle activity has frequently been characterized using average speed and vehicle miles traveled (VMT), however advances in modeling of mobile sources have increased the resolution in vehicle activity necessary for using the new models to their full capabilities. Recently, two GPS (Global Positioning System)-based vehicle activity datasets have become available from several different research programs. In 2001, the California Department of Transportation (Caltrans) conducted their 2001 California Statewide Household Travel Survey Program, which contains GPS-based data sets from across the state. This data set is approximately 125 MB in size and represents about 272 households. This database was divided into two parts, one corresponding to Northern California trips and the other corresponding to Southern California trips. Further, the Southern California Association of Governments (SCAG) carried out a post-census travel survey in 2001, which contains a number of GPS-datalogger datasets. This data set represents approximately 467 households.

The University of California College of Engineering-Center for Environmental Research and Technology (CE-CERT) has had extensive experience in designing, conducting, and performing data analysis for vehicle activity studies. In this research project, the CALTRANS and SCAG datasets were extensively examined, extracting vehicle activity information for better characterization of vehicle activity. These datasets were originally created to provide backup information to written travel surveys. Since these data acquisition programs were carried out across a wide range of representative households, it was felt that under further analysis, these data could provide useful information in characterizing vehicle activity for creating accurate mobile source emissions inventories. Three primary research tasks were carried out: 1) Specific vehicle activity data sets were acquired, pre-processed, and organized into a vehicle activity database; 2) Data analysis was performed on the two vehicle activity datasets, consisting of an examination of vehicle starts, as well as global trip characteristics (e.g., number of trips, trip length, and diurnal patterns; for comparisons between Northern and Southern California, the Caltrans database was utilized exclusively); and 3) A detailed speed-acceleration histogram analysis was performed, examining the velocity trajectory characteristics in the vehicle activity database. This was performed across different roadway facility types.

Based on this analysis, several general conclusions were made: 1) The average distance per trip was relatively short (4 to 6 miles) with an average trip duration around 8 to 12 minutes, with trips slightly shorter in distance but longer in duration in Southern California compared to Northern California (based on the Caltrans dataset); 2) The number of trips per day per vehicle was approximately 5 for both data sets; 3) The household-based datasets showed that there were little differences of travel from Monday – Friday, however on Saturdays and Sundays, the trips were significantly reduced—this is likely due to the fact that very little data was collected over the weekends; 4) An analysis of the diurnal trip patterns for the two household datasets did not show a typical commute pattern with a distinctive AM morning peak and a PM afternoon peak. Instead,

most activity peaked during the early afternoon in a single mode distribution; 5) An analysis of the soak time periods of the vehicles showed a two-mode distribution, where one peak occurring for 10 minutes or less (30% of the distribution and the other less pronounced peak occurring in the range of 120 – 360 minutes (13.5% of distribution); 6) After disaggregating the dataset by roadway facility type, it was seen that approximately 55% - 65% of VMT occurs on freeways, and the remaining 35% -45% occurs on surface streets; 7) In contrast, trip time spent on highways is approximately 35% - 45% while for surface streets, it was approximately 55% - 65%; 8) Average speeds were significantly higher on highways (as expected) compared to surface streets—Northern California had slightly higher speeds overall (based on the Caltrans dataset); 9) A number of speed-acceleration parameters and speed-acceleration frequency distributions were evaluated across the vehicle activity databases; as expected, surface streets displayed greater speed-acceleration fluctuation compared to highway travel.

Based on this study, some of the results can be used to update the vehicle activity portion of CARB's emissions inventory process. Several additional recommendations are as follows:

1) It is now possible to create roadway facility specific emission factors for the different kinds of driving that occur on the different road types. This can be accomplished by taking the driving snippets from the corresponding facilities and running them through a modal emissions model (weighted for a specific fleet). This would then allow for a link-based emissions inventory process where activity is measured on a link-by-link basis then multiplied by the corresponding emissions factor.

2) Similarly, it is possible to create representative "driving cycles" that correspond to specific roadway facility types. These driving cycles could also be used to create facility-specific emission factors through a real-world test program.

3) Now that appropriate analysis tools have been developed for processing GPS-based vehicle activity datasets, it is now possible to carryout additional vehicle activity studies at a fairly low cost. It is not very expensive to put in GPS dataloggers into representative vehicles and use those vehicles as "probes" to determine traffic and activity conditions. Of particular interest would be a truck travel pattern study.

4) Hybrid electric and plug-in hybrid electric vehicle energy management strategies can be optimized using these vehicle activity data. Since the vehicle activity is representative of real-world driving patterns, the energy management of a charge-sustaining strategy or zero emission range can be optimized based on the data sets.